

IN THE SPECIFICATION:

Please amend the specification as follows:

Please amend paragraph number [0003] as follows:

[0003] State of the Art: One type of electronic assembly containing semiconductor components is generally referred to as a “card”. “card.” Examples of such “cards” include multi multimedia cards such as used in digital cameras and the like, memory cards, smart cards, and personal computer memory card international association (PCMCIA) cards. The instant patent application refers to these types of cards as “semiconductor-cards”.“cards.” These cards are sometimes referred to as “daughter-boards”.“boards.”

Please amend paragraph number [0004] as follows:

[0004] Typically, a semiconductor card comprises a substrate which may be a thin printed circuit board (PCB) upon which electronic components are mounted. Such components may include, for example, at least one semiconductor die and/or die package as well as resistors, capacitors, inductors and the like to form a desired circuitry. The substrate includes conductors for providing power supply and interconnection of the various components. Typically, the components are mounted on one side, i.e. i.e., “circuit” side of the substrate, and are electrically interconnected to external contacts on the opposing side by interlevel conductors. The external contacts are arranged for electrical contact with a next level package, i.e. i.e., mother board. In use in an exemplary electronic apparatus apparatus, such as a digital camera, the card may be inserted into a slot or other receiver for interconnection with a motherboard, and provide for example, flash memory for digitally recording images.

Please amend paragraph number [0007] as follows:

[0007] A further requirement for semiconductor cards is that the peripheral outlines and card dimensions be as uniform as possible, so that proper effective insertion into a card receiver is assured. Specifications on the peripheral outline and dimensions of semiconductor cards have been set by various industry standard setting bodies, e.g. e.g., PCMCIA.

Please amend paragraph number [0008] as follows:

[0008] In present methods of manufacture, components for several semiconductor cards are fabricated and wire bonded on a strip of ~~e.g.~~ e.g., circuit board. The strip may be viewed as equivalent to the lead frame in die manufacture. The individual cards are then separated from the strip using a singulation process such as sawing. Often the singulation step produces slivers, and forms substrate edges which are rough or sharp. These defects can adversely affect the peripheral outline, dimensions, appearance and use of the card.

Please amend paragraph number [0011] as follows:

[0011] The semiconductor card includes a substrate such as a printed circuit board (PCB). The substrate comprises an electrically insulative material such as an organic polymer resin reinforced with glass fibers, and may include more than one layer. The substrate has a circuit side with a pattern of conductors thereon, and an opposing back side with a pattern of external contacts thereon. ~~Electronic~~ components components, such as semiconductor dice, resistors, capacitors, and ~~the~~ like like, are formed or mounted on the circuit side of the substrate. The semiconductor dice may comprise bare dice wire bonded to the conductors, bumped dice flip chip mounted to the conductors, or semiconductor packages bonded to the conductors. A single molding step serves to encapsulate the circuit side of the substrate and simultaneously form card surfaces and edges with smooth rounded or oblique corners.

Please amend paragraph number [0012] as follows:

[0012] A substrate may be initially formed as a segment of a substrate strip containing more than one module having a substrate separated therefrom by a peripheral opening. The strip is similar in function to a semiconductor lead frame, and permits various fabrication processes to be performed on one or more ~~substrate~~ substrates at the same time. The substrate is connected to the strip with connecting segments similar to tie bars on a semiconductor lead frame.

Please amend paragraph number [0013] as follows:

[0013] A molding assembly is adapted to form a plastic body larger than the substrate,

and simultaneously encapsulates circuit ~~components~~ components, such as dice, resistors, capacitors, bond wires, ~~etc.~~ etc., on the substrate as the card body is formed. Plastic wings are also formed by molding, extending outwardly from a central portion of the card edges along major sides of the card periphery.

Please amend paragraph number [0044] as follows:

DETAILED DESCRIPTION OF THE INVENTION

[0044] The invention is described and illustrated herein below in terms of a semiconductor card 10 which is exemplified by a “multimedia card”. card FIGS. 1 through 4 illustrate an improved semiconductor card 10 constructed in accordance with the invention. The semiconductor card 10 includes a substrate 12 (see FIG. 4) and at least one semiconductor element 16 (see FIG. 4) mounted to the substrate. The semiconductor card 10 also includes a plastic body 14 which is molded to portions of the substrate 12, and an array of external contacts 18 (see FIG. 3) on the substrate 12 for electrical connection with another circuit. Thus, for example, a semiconductor card 10 containing memory ~~(e.g.~~ (e.g., flash memory) may be configured for removable insertion into photographic devices for digital recording and retrievable storage of still pictures or video, and optionally audio.

Please amend paragraph number [0045] as follows:

[0045] As shown in FIGS. 1-4, semiconductor card 10 has a length 24, width 26 and thickness 28. The thickness 28 may typically be set at a desirable value in the range of about 1 mm to about 6 mm. In an exemplary ~~multi media~~ semiconductor card 10 described herein, the length, width, thickness and other aspects of the card may be set by an industry standards group, or alternatively the card configuration is decided by each manufacturer. In the particular example shown, the semiconductor card 10 has a length 24 of about 32 ~~mm~~, mm, a width 26 of about 24 ~~mm~~, mm, and a typical thickness 28 of about 1-3 mm. As depicted in FIGS. 1 and 2, the exemplary card may include a slightly depressed label area 30 for attachment or inking of a label (not shown) on the front face 20. The label area 30 is shown with an exemplary height 32 and width 34.

Please amend paragraph number [0046] as follows:

[0046] The front face 20 and back face 22 of the semiconductor card 10 are joined by a peripheral edge 36 having rounded corners 38. In accordance with the invention, the longitudinal edge 40 about the front face 20, and the longitudinal edge 42 about the back face 22 are shown as rounded to a radius 21 of ~~e.g.~~ e.g., about 0.20 ~~mm.~~ mm for ease of use. See FIG. 4A. As depicted in FIG. 4B, the longitudinal edges 40 and 42 may be alternatively “drafted” by molding an oblique face 23 on the edge.

Please amend paragraph number [0048] as follows:

[0048] In FIG. 5, a module 48 including substrate 12 is depicted as a thin sheet formed of an electrically insulating ~~material~~ material, such as an organic polymer resin reinforced with glass fibers. Suitable materials for the module 48 include bismaleimide-triazine (BT), epoxy resins (~~e.g.~~ e.g., “FR-4” “FR-4” and “FR-5”), and polyimide resins. Any of these materials can be formed as a sheet of the desired thickness, and then punched, machined or otherwise formed with a required peripheral configuration and with other desired features. A representative thickness of the sheet of module 48 can be from about 0.2 mm to 1.6 mm. The substrate 12 and surrounding frame 46 together comprise the module 48 having a width 50 and length 52. The module 48 may initially be a segment of a strip ~~44~~ 44, which is used to fabricate several semiconductor cards 10 at the same time. One or more substrates 12 may be formed from a strip 44, each substrate being defined by a peripheral opening 54 with inner edge 176 and outer edge 174. Non-substrate portions of the module 48 which surround the substrate ~~12~~ 12, are herein denoted as a frame 46. The ~~width~~ width 84 of the peripheral opening 54 is configured so that the peripheral outline 70 (hatched line of FIG. 5) of the produced semiconductor card 10 lies within the peripheral ~~opening~~ opening 54. The substrate 12 is connected to the frame 46 (and supported thereby) by a plurality of connecting segments 56, which are similar to tie bars used in lead frames for semiconductor manufacture. The peripheral opening 54 is shown as extending into the frame 46 on both sides of each connecting segment 56, in order to provide a desired segment length 58. A width 68 of each connecting segment 56 is ~~provided~~ provided, which

supports the substrate 12 during processing. The module 48 containing substrate 12 includes indexing openings 78 for aligning the substrate 12 with a cutting tool, not shown, and a molding apparatus 80 (not shown), described infra. The module 48 may contain other openings 82 (not shown) for other purposes.

Please amend paragraph number [0049] as follows:

[0049] As shown in FIG. 5, the peripheral opening 54 may be cut in module 48 to provide substrate 12 with a generally rectangular peripheral shape but with one chamfered corner 60. As shown in FIG. 1, the resulting semiconductor card 10 includes a chamfered corner 66. The purpose of chamfered corner 66 is to generally identify the end of the semiconductor card 10 having external contacts 18, and ensure that a user inserts the card in a proper orientation. However, the invention applies to a semiconductor card 10 or a substrate 12 of any shape. Also shown in FIG. 1 are exposed ends 56A of connecting segments 56 in the as-molded semiconductor card 10 after molding of the plastic body 14 and singulation from the frame 46. See also FIG. 3.

Please amend paragraph number [0050] as follows:

[0050] The substrate 12 includes a circuit side 62 (FIG. 5) and an opposing back side 64 (see FIG. 3), which in this embodiment comprises the card's ~~baek~~ back face 22. In FIG. 5, a longitudinal center line 94 of strip 44, and a longitudinal center line 96 of module 48 are shown for reference. A peripheral edge 72 (not shown) joins the circuit side 62 and the opposing back side 64 of the substrate 12. As illustrated in the exemplary substrate 12 of FIG. 5, the circuit side 62 has mounted therein semiconductor ~~components~~ elements 16, as well as electrical components 74, such as resistors, capacitors, and inductors. A circuit is completed by connecting the semiconductor ~~components~~ elements 16, electrical components 74 and external contacts 18 (see FIG. 3) with a pattern of conductors, ~~e.g.~~ e.g., wires, printed conductors, vias, and the like, not shown in the figures. Contacts (not shown) may also be provided to establish test circuits for example, typically on the circuit side 62 of the substrate. Methods and apparatus for forming, attaching and conductively interconnecting components 16, 74 and 18 are well

known in the art. The circuit on the substrate 12 may be configured to perform a desired ~~function~~ function, such as for example, memory storage, sound production, video production, games, product identification, etc.

Please amend paragraph number [0052] as follows:

[0052] In other processes for making semiconductor cards 10, ~~components~~ semiconductor element 16 and electrical component 74 together with other apparatus on the circuit side 62 are encapsulated with a glob-top material which is cured prior to forming the outer card surfaces. No such encapsulation is utilized in the present invention. As described herein, a method of the invention provides for a single encapsulation step by precise molding ~~which that~~ simultaneously encapsulates active components 16, 74 on the circuit side 62 of the substrate 12 and forms smooth outer surfaces of the semiconductor card ~~10~~ 10, including rounded or drafted (angular) peripheral ~~card~~ edges 36.

Please amend paragraph number [0053] as follows:

[0053] Regardless of the particular application to which the card circuit is directed, semiconductor card 10 of the invention includes a plastic body 14 which is molded directly to the circuit side 62 of substrate 12, covering ~~semiconductor-component(s)~~ element(s) 16, electrical component(s) 74 and exposed conductors, bond pads, ~~etc.~~ etc., which are mounted thereon. As shown in FIG. 6, the ~~molding-assembly~~ apparatus 80 is of a type generally characterized as a transfer mold with mating first ~~(e.g. (e.g.,~~ lower) plate 84 and second ~~(e.g. (e.g.,~~ upper) plate 86 with an interface 88 intermediate the two plates. As known in the art, such ~~molding-assembly~~ apparatus 80 will include an internal mold cavity 100 having internal surfaces 160A, 160B in the lower plate 84 and upper plate 86, respectively (see FIGS. 7 and 10), and alignment apertures 90 for precise joining of the plates. In addition, there are openings 92 for introduction of flowable polymeric molding compound (not shown) into the mold cavity 100. In addition, the ~~molding-assembly~~ apparatus 80 is modified in accordance with the invention to include a plurality of down-set pins 102 (see FIGS. ~~10-13, and 18~~ 11-13, and 18), which may be inserted downward along axes 104 in holes 106 passing through the upper plate 86, as explained further below.

Please amend paragraph number [0054] as follows:

[0054] Furthermore, the molding-assembly apparatus 80 is modified to form wings 148 of molded plastic material; the wings 148 extend laterally from areas between the rounded or drafted longitudinal-card edges 40, 42 along portions of the card's peripheral edge 36. Following extraction from the molding apparatus-64, 80, the wings-92 148 are excised by a smooth cut about the card's peripheral edge 36, providing a semiconductor card 10 with very little if any flash material, and with generally smooth longitudinal edges 40 and 42.

Please amend paragraph number [0055] as follows:

[0055] Turning now to FIGS. 7 through 9, which show the first (lower) plate 84 of a representative molding-assembly apparatus 80 for forming a semiconductor card 10 from a substrate 12. The first plate 84 has an upper side 140 with an internal mold-surface 160A, and a lower side or base 138. The first plate 84 includes a peripheral raised portion 108 to hold a module frame 46 at a first level 110. The outer edge 122 of peripheral raised portion 108 may be dimensionally smaller than the module 48. A depressed portion 112 laterally inside of the peripheral raised portion 108 is configured to accept a substrate 12 at lower level 114, with space for forming a plastic periphery about the substrate. The substrate is connected to the frame 46 by connecting segments 56. Portions 116 of the depressed portion 112 may be depressed further to accommodate external contacts 18 protruding from the back opposing back side 64 of the substrate 12. Laterally intermediate the peripheral raised portion 108 and the depressed portion 112 is a lower edge portion 118 of the lower mold-plate 84. The lower edge portion 118 has an inner arcuate surface 120 for forming rounded corners 38 and rounded longitudinal edges 40, 42 on the semiconductor card 10. The lower edge portion 118 passes upward through the peripheral opening 54 of the module 48, and in some locations, its upper surface 124 generally abuts the upper plate 86 to form a flash free seam on the peripheral edge 36 of the semiconductor card 10. As shown, a plurality of slits 126 are formed through the lower edge portion 118 and ~~raised~~ peripheral raised portion-126 108 for passage of connecting segments 56 of the module 48 therethrough. The numbers and locations of the plurality of slits 126 (and

matching substrate connecting segments 56) provide for downwardly motivated support of the substrate 12 in the depressed portion 112.

Please amend paragraph number [0056] as follows:

[0056] FIGS. 10 through 17 illustrate an upper molding-plate 86 configured to contact the circuit side 62 of the substrate 12. The upper molding-plate 86 has and an upper side 142 and a lower side 144. The upper plate 86 is inverted in the figures for viewing the internal mold cavity 100 with an internal mold-surface 160B in the lower side 144. Shown are alignment apertures 90, a raised peripheral portion 128 (with boundary 132) for contacting the upper surface 47 of frame 46, and injection ports 130 along plate edge 162, through which pressurized fluid polymer 15 is introduced into the mold cavity (see FIGS. 16 and 17). References to portions of the second i.e. second, i.e., upper plate 86 as being “raised” or “depressed” refer to the plate as in the inverted position, i.e. i.e., with the lower side 142 144 facing up, and the upper side 140 142 facing downward. This is particularly evident in the sectional views in FIGS. 12, 13, 15 and 17.

Please amend paragraph number [0057] as follows:

[0057] The mold cavity 100 includes a central depressed region 134 defined by arcuate or drafted walls 136. In addition, outward cavity extensions or “wing cavities” 150 are shown on four sides of the central depressed region 134. Each wing cavity 150 has an outer sloped or rounded wall 152 for ease of mold release. Thus, the central depressed region 134 is at a level 154 below the level 158 of lower side 144. A step 146 upward from central depressed region 134 attains an intermediate level 156 forming the base of each wing cavity 150.

Please amend paragraph number [0058] as follows:

[0058] As shown in FIG. 17, FIGS. 16 and 17, each injection port 130 may communicate with a runner 130A and a gate 130B for introducing liquified pressurized fluid polymer 15 into the mold cavity 100 at a controlled rate. The molding-assembly apparatus 80

may also include vents, not shown, for discharging air from the runners 130A and mold cavity 100, as known in the art.

Please amend paragraph number [0059] as follows:

[0059] Another feature of the upper plate 86 comprises a plurality of down-set pin through-holes 106, each located above a connecting segment 56. See FIGS. 10, 11, 12 and 13. A down-set pin 102 may be inserted in each hole 106 to motivate the connecting segments 56 and attached substrate 12 downward into and against the depressed portion 110 112. Entry of liquid polymer to the backside back face 22 of the substrate 12 is thus prevented.

Please amend paragraph number [0060] as follows:

[0060] The down-set holes 106 and pins 102 are positioned entirely within the wing cavities 150, outside of the peripheral edge 36 of the semiconductor card 10. The down-set pin 102 is shown as being generally cylindrical with an outer end 166 and an inner end 164 (see FIG. 13) which may be of reduced size. In the figures, the inner end 164 is shown as having a hemispherical shape with chamfered edges, but any shape which effectively clamps a connecting segment 56 against the depressed portion 110 112 may be utilized. For example, the inner end 164 may be square, rectangular, quarter round, lunate, etc. The holes 106 and down-set pins 102 are preferably configured so that the inserted down-set pins 102 are always in the same position relative to the substrate 12. As shown herein, the configuration of the molding apparatus 80 and the configuration of module 48 must be compatible.

Please amend paragraph number [0061] as follows:

[0061] FIGS. 18, 19 and 20 show portions of a molding apparatus 80 assembled for forming an encapsulating polymeric plastic body 14 on a substrate 12 of a module 48. The dimensions of various parts are not necessarily to scale.

Please amend paragraph number [0062] as follows:

[0062] In FIG. 18, a module 48 is shown inserted between the upper side 140 of a first

or lower plate 84 and the lower side 144 of a second or upper plate 86. The module section is shown with a frame 46, a substrate 12, and one of the four connecting segments 56 linking the substrate to the frame. The connecting segment 56 has an inner end 170 and an outer end 172. The connecting segment 56 is shown pushed downward by the inner end 164 of one of the down-set pins 102 into the depressed portion 112 of the lower plate 84. The displacement 155 of the substrate 12 from the frame 46 may be small, *i.e.* i.e., about 1/5 of the substrate thickness 13, or may be up to about 3 three times the substrate thickness, thickness 13, depending on the thicknesses of substrate and semiconductor card 10.

Please amend paragraph number [0063] as follows:

[0063] The substrate 12 is shown with a circuit side 62 on which are mounted exemplary semiconductor components elements 16 with connecting bond wires 17. The substrate 12 is held downward to depressed portion 112 (not shown) by the connecting segments 56, generally preventing passage of polymeric mold compound pressurized fluid polymer 15 (not shown) onto the substrate's back opposing back side 64. For reference purposes, the peripheral opening 54 over the majority of the substrate 12 generally has a width 55 extending from the inner end 170 to the opening's outer edge 174 (see also FIGS. 19 and 20).

Please amend paragraph number [0064] as follows:

[0064] In FIG. 18, the central depressed region 134 forming the front face of the molded semiconductor card 10 is shown with a slightly indented label area 30 in which a label may be applied. In addition, FIG. 18 depicts a final singulation plane 168 relative to the molding assembly apparatus 80. The semiconductor card 10 will be singulated from the frame 46 and wings 148 following removal from the molding assembly apparatus 80.

Please amend paragraph number [0065] as follows:

[0065] Following molding and solidification of the casting in the molding assembly apparatus 80, the unsingulated semiconductor card 10 may be ejected from the mold by further

insertion of down-set pins 102, or use of other pins, not shown. Ease of ejection is enabled by the use of sloped lateral surfaces and rounded or oblique corners on the molded casting 180.

Please amend paragraph number [0066] as follows:

[0066] FIG. 19 depicts the molding-assembly apparatus 80 with the module frame 46 and substrate 12 at a position away from a connecting segment 56. Shown are wing cavities 150 in which wings 148 are formed. The lower edge portion ~~118~~ 118, which surrounds the mold cavity 100 in the lower plate ~~84~~ 84, fits within the peripheral opening 54 between edges 174 and 176. The lower edge portion 118 molds an inner arcuate ~~or~~ or oblique corner surface 120 on the molded semiconductor card 10.

Please amend paragraph number [0067] as follows:

[0067] FIG. 20 depicts the molding-assembly apparatus 80, substrate 12 and module frame 46 in a portion where there is a substantial absence of wing cavities 150, and the substrate has external contacts 18 on its opposing back side 64. As shown, a cavity 178 is formed in the lower plate 84 into which the external contacts 18 fit. The external contacts, contacts 18, or even the entire opposing back side ~~64~~ 64, may in addition be covered by tape or other protective member (not shown) to ensure freedom from flash material on the card's back side.

Please amend paragraph number [0068] as follows:

[0068] In FIG. 21, a molded casting 180 molded on a semiconductor card module 48 is shown in front view following removal from the molding-assembly apparatus 80. The card module 48 includes a molded card plastic body 14 with molded wings 148 extending outwardly therefrom along major peripheral edges 36. The card plastic body 14 has a width 26 and length 24. The peripheral openings 54 are now filled with hardened molding material pressurized fluid polymer 15, including on both sides of each connecting segment 56. The card plastic body 14 is connected to the module 48 along a central portion of its peripheral edges 36, and its upper and lower peripheral longitudinal edges 40, 42 are smooth, rounded or oblique, and substantially free of "flash" flash material. This is evident by examination of FIGS. 22, 23, 24

and 25. The semiconductor card 10 has a back-side face 22 comprising the opposing back side 64 of the substrate 12. The semiconductor card 10 is singulated from the module 48 by cutting it free along its peripheral edges 36, i.e. i.e., through the wings 148, by saw, erosion process or other cutting tool. The four small exposed ends 56A of the connecting segments 56 (see FIG. 1), which project from card edges 56 connecting segments 56, may be easily trimmed (if desired) by clipping or other methods. Alternatively, the exposed ends 56A may be pre-scored, i.e. i.e., prior to molding, to minimize protrusion of the exposed ends 56A from the card edges connecting segments 56.

Please amend paragraph number [0069] as follows:

[0069] In the manufacture of the semiconductor card 10 of the invention, the steps involved may be summarized as including:

- a. A strip 44 of a dielectric material is provided in sheet form;
- b. A peripheral opening 54 is formed in at least one portion of the strip 44 designated as a module 48, in which the peripheral opening 54 defines the boundaries of a substrate 12. Opposing sides of the substrate 12 is are connected to a frame portion 46 of the module 48 by connecting segments 56 of the module 48. Other openings 82 for indexing and handling are also provided.
- c. A circuit 73 is formed on the “circuit” side 62 of the substrate 12, including at least one semiconductor component element 16 16, as well as electrical component(s) 74 and interconnecting conductors.
- d. External contacts 18 are formed on the opposing back side 64 of the substrate 12 and connected to circuit 73.
- e. A set of mold plates 84, 86 is are configured for molding a polymeric plastic body 14 peripherally 14 peripherally about the circuitized substrate 12 and over portions of the circuit side 62 thereof. Down-set pin holes 106 are provided outside of the card is peripheral outline 70 in an upper mold plate 86 for insertion of down-set pins 102 to motivate the connecting segments 56 (and attached substrate 12) downward to a lower level against a lower surface of the internal molding mold cavity 100 in the lower mold plate 84.

- f. The lower ~~mold~~-plate 84 and upper ~~mold~~-plate 86 are assembled with module 48 therebetween. The molding-assembly apparatus 80 is connected to a supply of molding compound and clamped shut. Down-set pins 102 are positioned in the holes 106 to force the substrate 12 downward to a seated position.
- g. ~~Fluid polymeric molding compound~~Pressurized fluid polymer 15 is introduced into the molding-assembly apparatus 80 under conditions which rapidly fill the mold cavity 100, encapsulating the circuit 73 and forming a plastic body 14.
- h. After curing and cooling of the ~~mold material~~pressurized fluid polymer 15, the mold is opened and the molded module 48 removed therefrom. Pins may be inserted in ~~through~~holes 106 and used as ejection tools for releasing the module.
- i. The semiconductor card 10 is singulated from its module 48 by cutting along the card is peripheral outline 70.
- j. If desired, exposed ends 56A of the connecting segments 56 within the semiconductor card 10 may be cut back. If necessary, flash residue may be removed.

Please amend paragraph number [0070] as follows:

[0070] In another embodiment of the invention, the molding ~~assembly~~ apparatus 80 may be configured to cover portions of both ~~sides~~ faces 20, 22 of a substrate 12. The ~~molding~~ mold cavity 100 of lower plate 84 is varied by providing one or more additional cavities and associated runners for introducing ~~bonding compound~~ pressurized fluid polymer 15.

Please amend paragraph number [0071] as follows:

[0071] As described herein, the invention provides a semiconductor card by a method ~~which~~ that eliminates a separate glob top encapsulation step, and ensures smooth card edges which are rounded or oblique. Desired card dimensions are readily maintained, and flash material requiring removal is minimized. If desired, the molding assembly may be configured to form several cards simultaneously.